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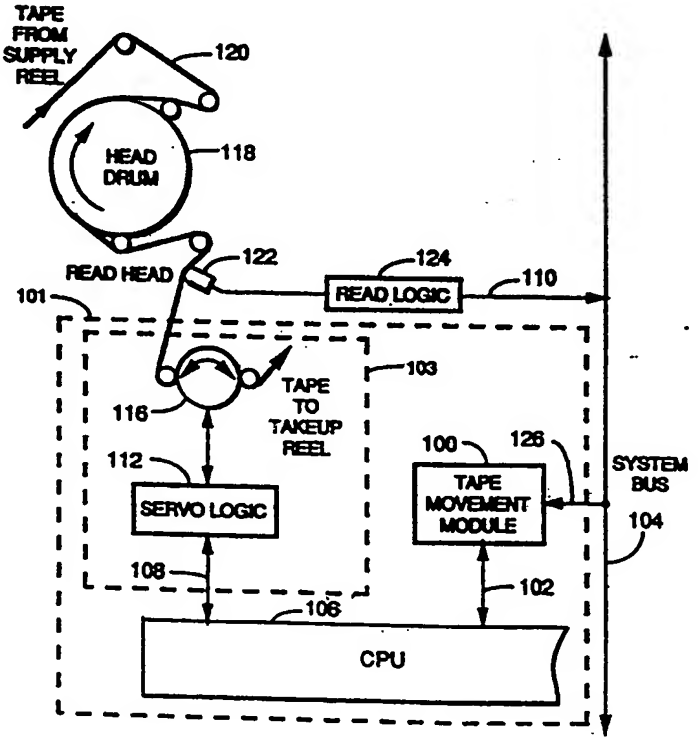
(54) Title: METHOD AND APPARATUS FOR MINIMIZING TAPE WEAR IN A TAPE RECORDING AND REPRODUCING SYSTEM

(57) Abstract

A method and apparatus incorporated in a magnetic tape drive serving as a non-video data processing peripheral provide for magnetic tape wear protection during periods of time when the tape is stationary relative to a rotating head drum around which the tape is at least partially wound. A variably patterned tape movement sequence and a tape protection sequence are initiated in response to a host-directed tape stop instruction thereby keeping the tape wear at any particular spot on the tape to a minimum. These sequences, while in force, may be overridden by a subsequent tape move instruction coming from the host.



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METHOD AND APPARATUS FOR MINIMIZING TAPE WEAR IN A TAPE RECORDING AND REPRODUCING SYSTEM

FIELD OF INVENTION

The present invention relates to magnetic tape recording/reproducing systems, and more particularly to a method and apparatus within such a system for protection against magnetic tape wear.

DESCRIPTION OF THE RELATED ART

In recent years, super computers and high-end workstations have placed more stringent demands on large-scale mass storage devices especially regarding capacity and speed. Magnetic disk peripherals, because of high data transfer rates, are currently being used as on-line storage for these systems. Magnetic tape drives, on the other hand, although offering virtually unlimited capacity and better cost economics than those of disk drives, suffer from low data transfer rates.

By applying the state-of-the-art video recording rotary head technology to the high-end computing environment, tape drive information transfer rate shortcomings can be resolved, thereby making tape drives feasible as large capacity and low cost, potentially on-line mass storage devices. However, with its advent into the digital computing world where each data bit is critical, rotary head technology must address the question of magnetic tape wear protection properly without significantly compromising performance.

Video tape recorders were first commercially available in the 1950's primarily to compensate for the continental time differential in the U.S. These magnetic tape recording and reproducing devices revolutionized television broadcasting within a few years of its introduction. The Quadruplex configuration, in particular, used a rotary head method scanning transversely across a magnetic tape. Because of its video recording quality at the time, it had dominated the broadcast industry in the next two decades.

In the late 1970s, the helical scan recorders took over the markets ranging from consumer to broadcast. Instead of guiding a tape to mate transversely with rotating heads, as in the Quadruplex system, the tape is wrapped spirally around a cylindrical drum, containing either a centrally located rotating head panel or a rotating upper half to which the head tips are mounted.

Both configurations have a high rotational head drum speed relative to the tape speed. Consequently, physical tape wear and tear generated by the head drum to tape contact remains a design concern, particularly during data processing on a tape which has been formatted in such a way that there is a high probability of the tape stopping at the same location repeatedly. Therefore, during read and write operations, for non-video digital data, utilizing tape-rotary head technology for a computer peripheral, such as a magnetic tape storage device, the tape wear difficulty is intolerably exacerbated. Since a computer host has many tasks in addition to catering to its peripherals, data read and write operations may require frequent tape stoppages in midst of data transfers. Moreover, these tape movement interruptions often times repeatedly involve head drum contact in the same tape areas because of the way the data is logically formatted. For example, typical physically positioned areas of the tape format correspond logically to the beginning of tape (BOT), beginning of file (BOF), end of file (EOF), end of record (EOR) and multiples of data transfer buffer size from BOF, or from EOR in a partitioned tape arrangement. During data file read and write operations on tapes having such a format, such tape markers are utilized for the initial tape positioning for performance of read and write operations thereafter, as a consequence of which there is a high probability of repeated contact between the tape and head drum at these particular locations. It is these tape to head drum contact areas where repeated tape movement stoppages occur that occasion excessive tape wear such as helical scratches, oxide losses, and tape breakage, any or all of which may result in uncorrected errors arising from tape wear in the data processing environment and which may render the entire data file in question useless. A need therefore exists for reducing tape wear resulting from a stationary magnetic tape in contact with a rotating head drum without significantly affecting the data transfer performance.

In accordance with an aspect of the invention, there is provided a method and apparatus for reducing magnetic tape wear resulting from frictional contact between a stationary magnetic tape and a rotating head drum.

Another aspect of the invention is to provide a apparatus and method which can be utilized without significantly affecting the data transfer performance.

SUMMARY OF THE INVENTION

The foregoing and other objects are accomplished by providing a method and apparatus for magnetic tape wear protection during periods of time when the tape is stationary relative to a rotating head drum around which the tape is at least partially wound. Immediately upon a host-initiated cessation of the tape movement, while idling, under control of a processor, an event and a signal are initiated. The event being an initiation of a time out period and the signal being a signal to enable commencement of movement of the tape at a slow speed in accordance with a predetermined programmable pattern or sequence. With the tape movement pattern continuing for the duration of the time out period, after which, if there has been no intervening data transfer instruction, a time out signal is generated initiating a tape protection sequence which includes disengaging the tape from contact with the head drum. Normally, in the case of writing on a new tape, such movement would be a slow reverse movement for the duration of the time out period, since the tape marking events, such as formatting on the tape BOF, EOR and the like, are normally written during the first write of new data on the tape.

This motion reduces the risk of tape attrition damage on a particular tape segment while the tape drive is idling. This variably patterned tape motion can also keep system performance loss to a minimum by having the tape segment in contact with the rotating head drum remaining in close proximity to the position at which the tape had originally stopped. Furthermore, this invention can be implemented simply and inexpensively.

Accordingly, the present invention relates to apparatus and method for tape wear protection of a stationary magnetic tape segment in contact with a

rotating head drum during or in between information transfer, which includes the operative steps f: a) receiving a tape movement control signal such as a tape stop signal; b) controlling a variably patterned tape movement sequence dependent on the tape stop signal; and c) moving a magnetic tape responsive to a command issued controlling the variably patterned tape movement sequence. The variably patterned tape movement sequence comprises a variety of tape movement patterns, for examples, moving the tape in a tape reverse direction, moving the tape in a tape forward direction, moving the tape in both directions about a particular tape segment, moving the tape in a continuous manner, moving the tape intermittently, and etc. Preferably, the motion is continuous at a "creep" speed level in a tape reverse direction.

Logical tape addresses are read and stored as the tape moves in accordance with the established sequence or pattern. The speed of the tape movement is adjustable but preferably slower than the typical tape read/write speed for better system performance. If the movement sequence has exceeded a pre-specified amount of time, a tape protection sequence may be executed including but not limited to a tape unthreading sequence separating the tape from the head drum.

A data read or write signal initiated by the host or other peripheral devices during the tape movement sequence, but before the time-out period, will act to override either the movement sequence or the tape protection sequence. More specifically, either sequence would be in force until the external processor is ready to communicate with the tape drive once more.

The above objects and advantages of the present invention will become apparent to those skilled in the art after having read the following detailed description in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a functional block diagram depicting a portion of a processor-controlled tape drive apparatus including a tape servo mechanism which is controlled in accordance with the preferred embodiment f the invention.

Figure 2 shows a segment of a digital data tape having a logical data format for use in the apparatus of Figure 1.

Figure 3 is a block diagram of a tape protection sequence apparatus in accordance with the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to the drawings, and more particularly, to FIG. 1, there is shown a tape wear protection apparatus, generally designated 101. The apparatus includes a tape movement module 100, a central processing unit (CPU) 106, and a tape transport assembly 103. The apparatus may be a part of a magnetic tape drive.

As illustrated in FIG. 1, the tape movement module 100 is electronically connected to a system bus 104 via a path 126 and to the CPU 106 via a path 102. The tape movement module 100 preferably includes digital logic receiving a tape movement control signal on a regular basis, e.g. every 80 ms, from the system bus 104. Types of the tape movement control signal can be deciphered in the tape movement module 100. Of particular interest to the present invention is a tape stop signal and a tape move signal. Both signals can be either direct and express commands off the system bus 104, e.g. a TAPE STOP instruction, or indirect and implied, e.g., SEARCH EOF, BUFFER FULL. Regardless, both are related to the CPU 106 through the path 102. Another embodiment may merge the tape movement module 100 into the CPU 106.

The CPU 106 is connected to the tape movement module 100 via the path 102 and to the tape transport assembly 103 via a path 108. Moreover, the CPU 106 is capable of receiving a plurality of tape position information from the system bus 104 via a path 110.

In one embodiment, a tape stop confirmation may be obtained from the tape transport assembly 103 via the path 108 after a TAPE STOP signal is applied to the CPU 106 via the path 102 from an external source. After the tape is halted, while the magnetic tape drive idles, the CPU 106, via the path 108, applies specific tape movement instructions constituting a variably patterned tape movement sequence to the tape transport assembly 103 which comprising a servo logic 112 and a capstan 116. Because the tape transport assembly 103 operates in a manner which is known in the art, other transport gears associated with the servo logic 112 and the capstan 116 are not shown in FIG. 1 for simplicity sake. The capstan 116 moves a magnetic tape 120 preferably continuously in a tape reverse direction at a generally slow speed, e.g. 6% of the read/write speed.

As illustrated in FIG. 1-3, the plurality of tape position information is generated preferably from a plurality of read heads on a scanning head drum 118 as a portion of the magnetic tape 120 moves across the head drum 118. The tape position information is processed by a read logic and fed to the system bus 104. As stated above, read heads typically are mounted on or in the head drum. For purposes of simplicity and clarity, one representative read head 122, separated from the head drum 118, and its associated read logic 124, are shown in FIG. 1. Data is preferably read from the tape 120 in helical scan format.

A magnetic tape segment, generally designated 200 in FIG. 2 with the helical scan format includes three control tracks 208, a beginning of tape (BOT) 206, a user data zone 202 and a non-user data zone 204. The read head 122 and its associated read logic 124 generate the tape position information from one of the control tracks 208 such as a physical address track, before delivering it to the system bus 104. The CPU 106 obtains the tape position information off the system bus 104. At any time, the CPU 106 would know the exact location of where the tape 120 is in relation to the head drum 118.

The CPU 106 monitors elapsed time from the onset of the variably patterned tape movement sequence. When a pre-specified amount of time, a time out period, is reached, the CPU 106 generates a time-out signal causing a tape protection sequence to occur. To avoid any damage to the user data zone 202, this tape protection sequence includes but not limited to a search for the

tape non-user data zone 204 such as the tape's system zone, a search for the beginning of tape (BOT) 206, and a separation between the magnetic tape 120 from the head drum 118.

As an example, a magnetic tape separation from head drum 'unthreading' apparatus is shown in FIG. 3. Particularly, there is shown a head drum 118, a 'tilt' threading guide 312, 318 and a helix threading guide 314, 316 of the type as utilized for example in a digital video signal tape recorder/playback device VPR-300, manufactured by Ampex Corporation. Details of that particular device are described in VPR-300 Series Video Production Recorder Service Manual, Volume I, Catalog No. 1520528-02 issued by Ampex Corporation, Redwood City, California, August 1989.

As a magnetic tape 120 is halted while the head drum 118 continues to rotate, the CPU 106 initiates the variably patterned tape movement sequence and the time monitoring. This embodiment, later, in response to the time-out signal, would first move the tape so that the head drum contacts the tape system zone, if none, then the beginning of tape (BOT), after which, move the 'tilt' threading guide 312 and the helix threading guide 314 to their unthreaded positions, 318 and 316, respectively, whereby separating the tape 120 from the head drum 118.

Lastly, while either the variably patterned tape movement sequence or the tape protection sequence is in force, once the CPU receives the tape move signal from the tape movement module 100 via the path 102, an override occurs. The CPU 106 would cause the tape transport assembly 103 to stop either sequence. Necessary servo parameters such as tape direction and distance would be calculated from the tape position information and a destination address obtained from the tape move signal. The CPU 106 would then command the tape transport assembly 103 to move the tape 120 accordingly.

While this invention has been described in terms of preferred embodiments, it is contemplated that persons reading the preceding descriptions and studying the drawing will realize various alterations, permutations and modifications thereof. It is therefor intended that the following appended claims be interpreted as including all such alterations,

permutations and modifications as fall within the true spirit and scope of the present invention.

What is claimed is:

1. An apparatus for reducing wear of a segment of a magnetic tape in contact with a rotating head drum, which comprises:

means for receiving a tape movement control signal including a tape stop signal;

means for controlling tape movement dependent on said tape movement control signal including initiating a variably patterned tape movement sequence responsive to said tape stop signal;

means for moving said magnetic tape relative to said rotating head drum responsive to said controlling means.

2. The apparatus of Claim 1 wherein said controlling means includes a programmable control means.

3. The apparatus of Claim 2 wherein said controlling means receives during the variably patterned tape movement sequence a plurality of tape position information from said tape.

4. The apparatus of Claim 3 wherein said controlling means monitors elapsed time of said variably patterned tape movement sequence from its onset and generates a time-out signal responsive to said elapsed time, thereafter causing an initiation of a tape protection sequence.

5. The apparatus of Claim 4 wherein

said tape movement control signal including a tape move signal;

said controlling means, responsive to said tape move signal, overriding said variably patterned tape movement sequence and said tape protection sequence.

6. The apparatus of Claim 5 wherein said tape protection sequence includes a search sequence for a non-user data zone on said magnetic tape.

7. The apparatus of Claim 5 wherein said tape protection sequence includes a search sequence for a beginning of tape, BOT, of said magnetic tape.

8. The apparatus of Claim 5 wherein said tape protection sequence includes a separation of the magnetic tape from contacting said rotating head drum.

9. The apparatus of Claim 5 wherein said variably patterned tape movement sequence includes a magnetic tape motion in a generally slow speed.

10. The apparatus of Claim 9 wherein said magnetic tape motion travels continuously in a tape reverse direction.

11. A method for reducing wear of a segment of a magnetic tape in contact with a rotating head drum, which comprises the steps of:

receiving a tape movement control signal including a tape stop signal;

controlling tape movement dependent on said tape movement control signal including initiating a variably patterned tape movement sequence responsive to said tape stop signal;

moving said magnetic tape relative to said rotating head drum responsive to said controlling means.

12. The method of Claim 11 wherein said controlling step includes the step of programmable controlling said tape movement.

13. The method of Claim 12 wherein said controlling step includes the step of receiving during said variably patterned tape movement sequence a plurality of tape position information from said tape.

14. The method of Claim 13 wherein said controlling step includes the steps of monitoring elapsed time of said variably patterned tape movement sequence from its onset and generating a time-out signal responsive to said elapsed time, thereafter causing an initiation of a tape protection sequence.

15. The method of Claim 14 wherein

said receiving step including the step of receiving a tape move signal;

said controlling step including the step of overriding said variably patterned tape movement sequence and said tape protection sequence in response to said tape move signal.

16. The method of Claim 15 wherein said tape protection sequence includes a search sequence for a non-user data zone on said magnetic tape.

17. The method of Claim 15 wherein said tape protection sequence includes a search sequence for a beginning of tape, BOT, of said magnetic tape.

18. The method of Claim 15 wherein said tape protection sequence includes a separation of the magnetic tape from contacting said rotating head drum.

19. The method of Claim 15 wherein said variably patterned tape movement sequence includes the step of causing a magnetic tape motion in a generally slow speed.

20. The method of Claim 19 wherein said magnetic tape motion travels continuously in a tape reverse direction.

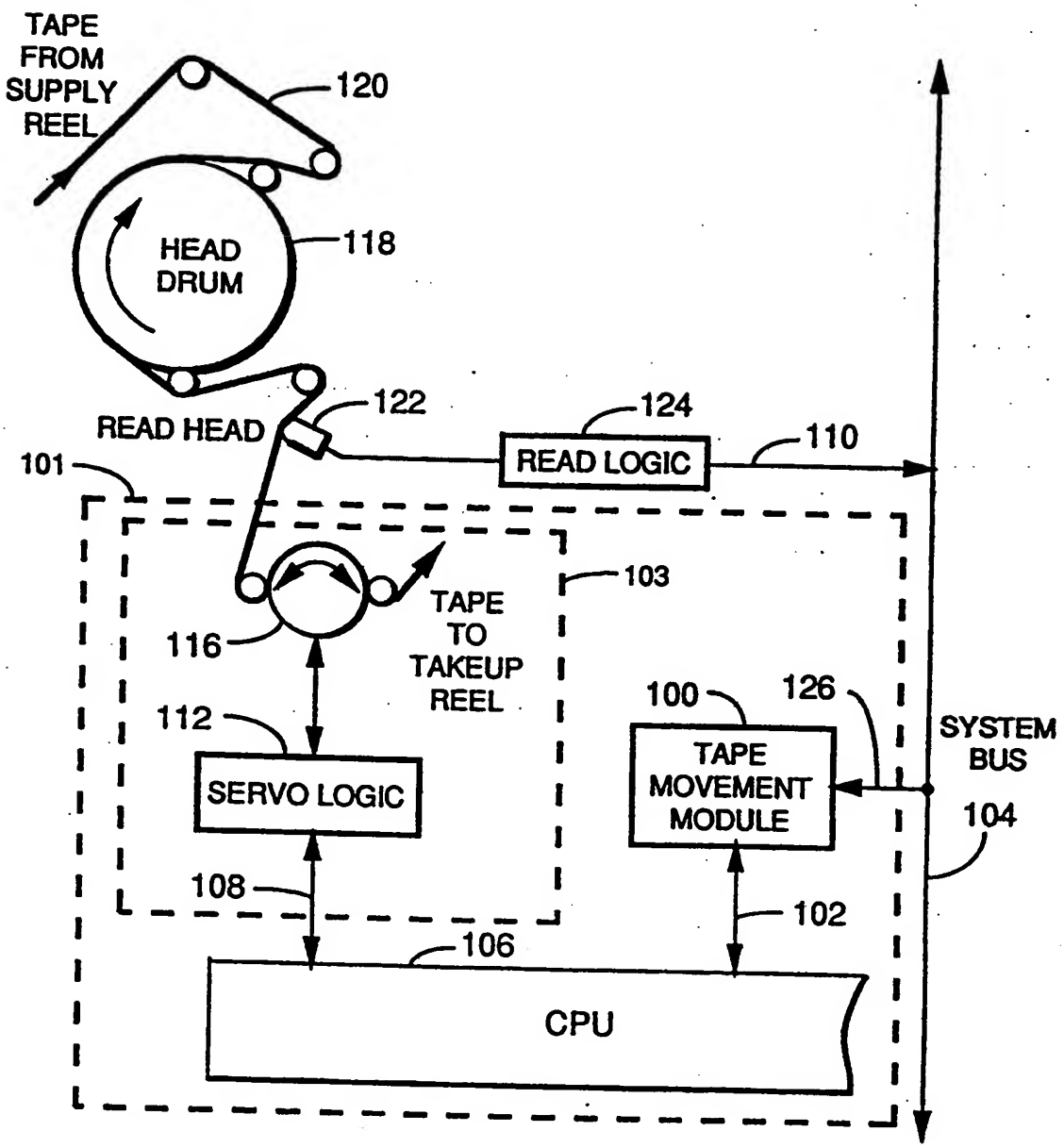
TAPE FROM SUPPLY REEL
120
HEAD DRUM
118
READ HEAD
122
124
READ LOGIC
110
101
103
TAPE TO TAKEUP REEL
116
112
SERVO LOGIC
100
126
TAPE MOVEMENT MODULE
SYSTEM BUS
104
108
102
106
CPU

FIG. 1

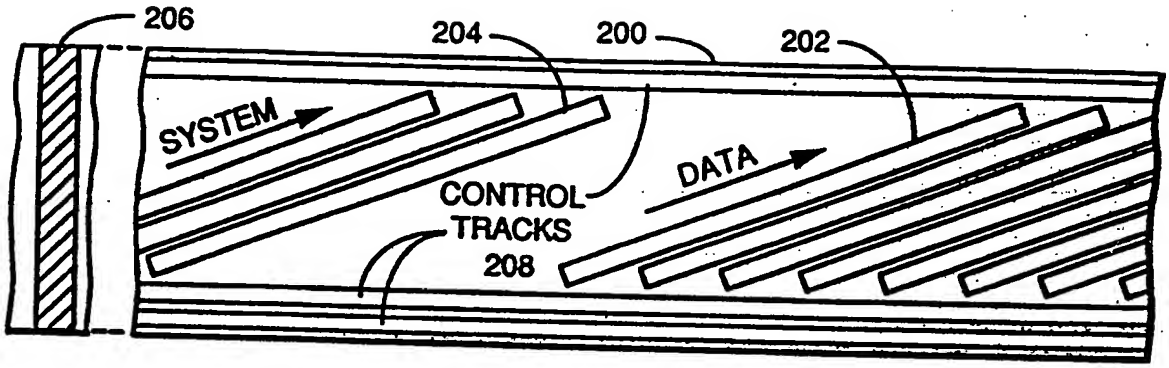
206
204
200
202
SYSTEM
DATA
CONTROL
TRACKS
208

FIG. 2

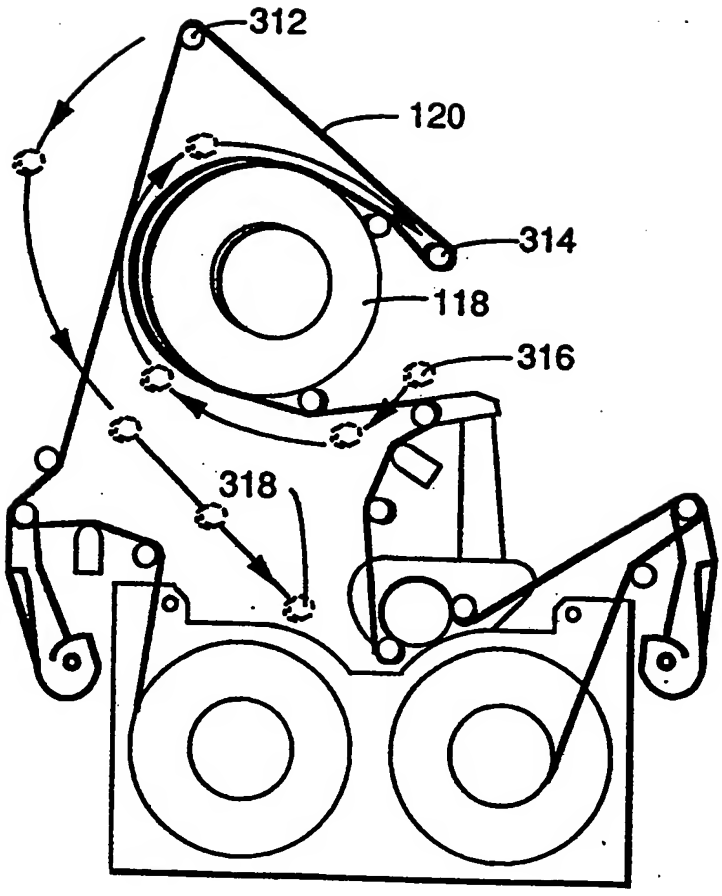
312
120
314
118
316
318

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 93/03319

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G11B15/20; G11B15/02; G11B15/665

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G11B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US,A,4 554 604 (TSUNEYUKI KOYAMA) 19 November 1985 see claims 1,7; figures	1,2,11, 12
X	EP,A,0 058 059 (MATSUSHITA) 18 August 1982 see page 8, line 29 - page 10, line 25; claims; figures	1,2,11, 12
X	EP,A,0 357 035 (SANYO ELECTRIC CO LTD) 7 March 1990 see claims; figures	1,2,11, 12
X	PATENT ABSTRACTS OF JAPAN vol. 10, no. 111 (P-451)25 April 1986 & JP,A,60 242 537 (TEAC KK) 2 December 1985 see abstract	1-3, 11-13

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12 JULY 1993	21. 07. 93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	SCHWANDER

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category*	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 7, no. 119 (E-177)24 May 1983 & JP,A,58 036 084 (SONY) see abstract	1-3, 11-13
A	EP,A,0 396 187 (PHILIPS) 7 November 1990 see column 11, line 25 - column 13, line 58; claims	1-4, 11-14
A	US,A,5 101 311 (ROBERT C. RICHMOND) 31 March 1992 see column 2, line 33 - line 68; claims; figures	1-20
A	EP,A,0 194 149 (MITSUBISHI) 10 September 1986 see page 9, line 10 - page 14, line 15; claims; figures	1-20
A	GB,A,2 113 451 (BELL AND HOWELL COMPANY) 3 August 1983 see page 3, line 56 - page 5, line 55; claims; figures	1-20

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

US 9303319
SA 73289

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-4554604	19-11-85	JP-B-	1036163	28-07-89
		JP-C-	1552473	23-03-90
		JP-A-	58203601	28-11-83
		JP-B-	1032582	06-07-89
		JP-A-	58208952	05-12-83
		JP-A-	58208960	05-12-83
		JP-A-	58220265	21-12-83
		DE-A,C	3318676	24-11-83
		FR-A,B	2527407	25-11-83
		GB-A,B	2122016	04-01-84
EP-A-0058059	18-08-82	JP-A-	57129584	11-08-82
EP-A-0357035	07-03-90	JP-A-	2066759	06-03-90
		US-A-	5045957	03-09-91
EP-A-0396187	07-11-90	AT-B-	391957	27-12-90
		JP-A-	2304758	18-12-90
		US-A-	5124860	23-06-92
US-A-5101311	31-03-92	CA-A-	2013181	09-05-91
		JP-A-	3158922	08-07-91
EP-A-0194149	10-09-86	JP-A-	61204853	10-09-86
		DE-A-	3682692	16-01-92
		US-A-	4700255	13-10-87
GB-A-2113451	03-08-83	US-A-	4385330	24-05-83
		GB-A,B	2091473	28-07-82
		GB-A-	2113452	03-08-83

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